Operation Iraqi Freedom (OIF)
Depleted Uranium (DU)
DoD Medical Management Policy

7th Annual Force Health Protection Conference

11 August 2004

Overview

- DU Exposure Health Risks and Health Physics
  David P. Alberth, MEd
  Master Consultant for Health Physics
  USACHPPM
- ASD(HA) Policy for the Operation Iraqi Freedom Depleted Uranium (DU) Medical Management
  R. Craig Postlewaite, DVM, MPH
  Chief, Environmental Health Team
  OSD(HA) Deployment Health Support Directorate
- Implementation of the ASD(HA) DU Policy
  Mary F. Vaeth, MD, MS, COL (USA Retired)
  Dori A. Rogut, APRN, BC
  Staff Training and Assistance Team
  DoD Deployment Health Clinical Center
- VA Depleted Uranium Follow-Up Program
  Melissa A. McDiarmid, MD
  Director, VA DU Follow-Up Program
  Professor, Department of Medicine, University of Maryland School of Medicine
  Katherine S. Squibb, PhD
  Associate Professor, Department of Epidemiology and Preventive Medicine
  University of Maryland, Baltimore

Potential Health-Related Risks and Health Physics Issues Associated with DU Exposure

David P. Alberth, M. Ed.
Master Consultant for Health Physics
USACHPPM

DU Introduction and History

- U.S. Military uses depleted uranium (DU) in anti-armor munitions and in protective armor in certain Abrams Tanks
- DU Munitions first used in Combat by DoD during Operation Desert Storm (1991 Gulf War)
- Since used by NATO during the Balkans Conflict (1990s) and by DoD in Operation Iraqi Freedom (2003)

Sources of Military DU Exposure

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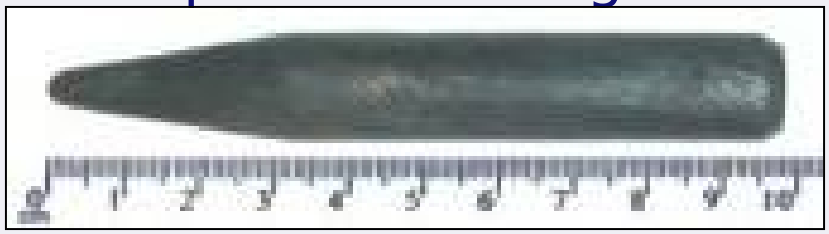
- Hard target impact and perforation of armored vehicles by DU munitions
- Vehicle fires involving DU munitions
- Subsequent environmental exposures through



Definition of Depleted Uranium (DU)

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- DU is a slightly radioactive heavy metal
- A very dense metal (1.7 times as dense as lead)
- A byproduct material of the uranium enrichment process used to obtain increased concentrations of uranium-235, resulting in enriched uranium for reactor fuel and nuclear weapon components
- Depleted uranium has a different isotopic mix than natural uranium, since it is "depleted" of both uranium-235 and uranium-234 (the relatively more radioactive of the uranium isotopes)

Radiological Characteristics of DU

- Specific activity of DU is low due to long half-lives of uranium isotopes
- DU 40% less radioactive than naturally occurring uranium
- Uranium emits α, β, and γ ionizing radiations
  - α - present in highest activity
    - Penetration of skin not possible so no external radiation risk
    - Potential hazard if inhaled, ingested or in contaminated wounds
  - β and γ - present in lower activities
    - Potential external radiation hazard
    - Also potential hazard if internalized

Chemical Characteristics of DU

- Causes toxicity as a heavy metal, similar to lead
- Toxicity depends on the solubility of the uranium compound (↑ solubility = ↑ toxicity)
- Kidney is the principal target organ
- Single depleted uranium exposure
  - Highly soluble component excreted by kidney in the first 24 hours
  - Highly insoluble component remains at deposition site until solubilized into bloodstream and redistributed to kidney, bones and other organs

Naturally-Occurring Uranium in Human Body

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- CDC National Report on Human Exposure to Environmental Chemicals (NHANES) provides an ongoing exposure assessment of the U.S. population to environmental chemicals using biomonitoring

- Results of uranium-in-urine analyses to date indicate:

  Mean value of urine uranium concentration occurring naturally in the U.S. population (95th percentile)
  as **0.046 microgram (46 nanograms)** uranium per liter of urine

Type of DU Exposure -External

- Exposure to Soldiers from **uploaded, intact munitions in armored vehicles** (e.g., Abrams tank, Bradley Fighting Vehicle) – less than occupational exposure guidelines
- Exposure to **fired, bare penetrator rounds found at battle site** – if handled with bare hands, Soldier can receive a measurable radiation dose to the hands, but not likely one in excess of guidelines

Type of DU Exposure -Internal

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- **Inhalation**
  - Soluble DU oxides absorbed and distributed to other organs
  - Less soluble DU oxides removed slowly
  - Particles <10 micrometers AED are respirable
- **Ingestion**
  - Absorption from gut is inefficient (~ 2%)
- **Wounds**
  - DU oxide particles may also enter through open wounds
- **Embedded fragments**
  - Retained in body
  - Slowly solubilize, transferring uranium to bloodstream and other tissues
  - Intact particles may be transported by macrophages

Effects of DU Exposure on the Human Body

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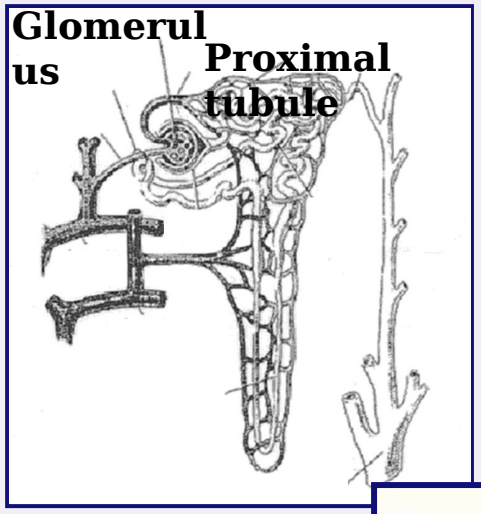
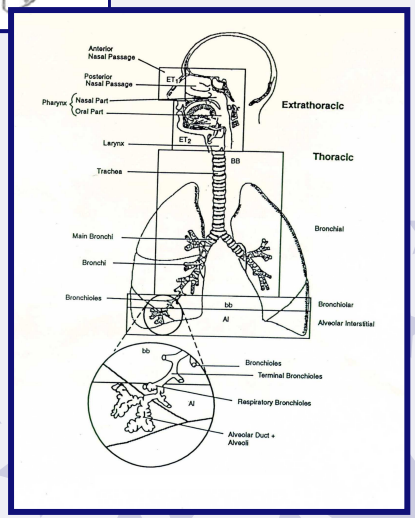
- Health concerns about DU predominately relate to its chemical properties as a heavy metal rather than to its low radioactivity
- The **kidney** is the target organ for chemical toxicity (soluble forms)
- The **lung** is the target organ for radiological concerns (insoluble forms)





Radiological Health Effects
External Radiation Exposure

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- External whole body doses from intact DU munitions and armor
  - Extensively studied
  - Doses well below occupational dose limits of 5 rem/year
- If munitions not intact, skin dose is about 0.2 rem/hour on contact
  - Handling a bare DU penetrator without gloves (after fire or clean-up of impact site)
  - Direct contact for 250 hours per year required to exceed occupational skin dose of 50 rem/year

Radiological Health Effects Internal Radiation Exposure

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- The lung is the primary target organ for radiological concerns (insoluble forms)
- Animal studies have suggested a potential for uranium-induced carcinogenesis
- Recent reports have explicitly stated the lack of association between DU and malignancy (ref. ATSDR, RAND, WHO)
- UK Royal Society has stated, except in extreme circumstances, any increased risk of fatal cancers resulting from internal radiation exposure to DU from battlefield conditions is likely to be so small as to be non-detectable above the general risk of a fatal cancer over a normal lifetime

Chemical Health Effects External and Internal Chemical Exposure

- External chemical exposure — None
- Internal chemical exposure
  - Kidney is the principal target organ
  - Effects on the kidney resemble those caused by other heavy metals, such as lead or cadmium
  - 3 micrograms of uranium per gram of kidney tissue is acceptable guideline for assessing internal exposures (ref. ICRP)
- Chemical toxicity may be the more limiting factor for soluble DU forms; however, military DU sources limit the availability of the more soluble forms

Factors Affecting DU Toxicity

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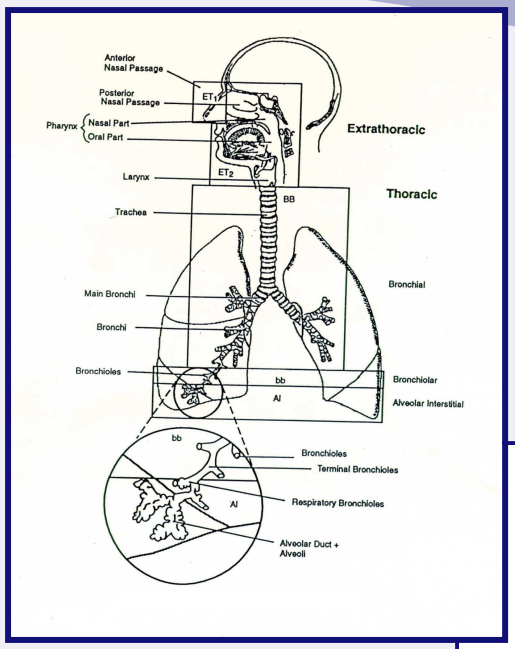
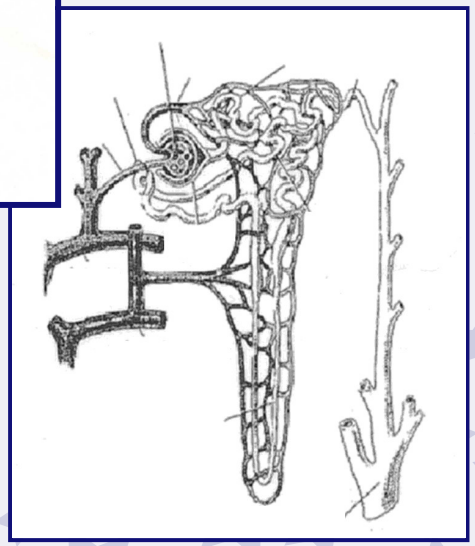
- Route of exposure
- Chemical form
- Amount internalized
- Solubility
- Particle size and distribution

Target Organs for DU

- Lung (insoluble forms)
- Kidney (soluble forms)
- Liver and bone (soluble forms)
- Ongoing research suggests other potential target organs





Initial Field Management of Patients with Potentially Embedded DU Fragments

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- Clean wounds and burns using standard surgical procedures. RADIAC meter may assist in locating DU contamination in wound or burn (consider depth of wound)
- Don’t delay life-saving treatment to obtain a RADIAC meter or urine collection for bioassay
- Document potential DU exposure and possible embedded DU fragments in patient’s Field Medical Record

DU Medical Treatment Points of Discussion

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- Amount internalized determines health risk
- DU chemical risk dependent upon solubilization (dissolution) of DU oxides and other chemical forms in body fluids
- Embedded fragments may not be DU

Follow-On Management of Patients with Potentially Embedded DU Fragments

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- Remove embedded DU fragments using standard surgical criteria. Fragments larger than 1 centimeter should be removed more aggressively unless medical risk is too great
- If indicated, monitor kidney function and begin urine collection for bioassay ASAP in medical evacuation chain for casualties with contaminated wounds or embedded fragments

DoD Example: Army Screening Program for OIF DU Exposures

In a USACHPPM review, **95% of Army urine bioassay results** have been **within the NHANES range of normal environmental uranium values**

[0 ≤ value ≤ 46 nanogram U/Liter urine]

# results	# ng U/L urine
940 (88%)	≤ 25
77 (7%)	25 < value ≤ 46
53 (5%)	> 46
1,070 (100%)	

DoD Example: Army Screening Program for OIF DU Exposures

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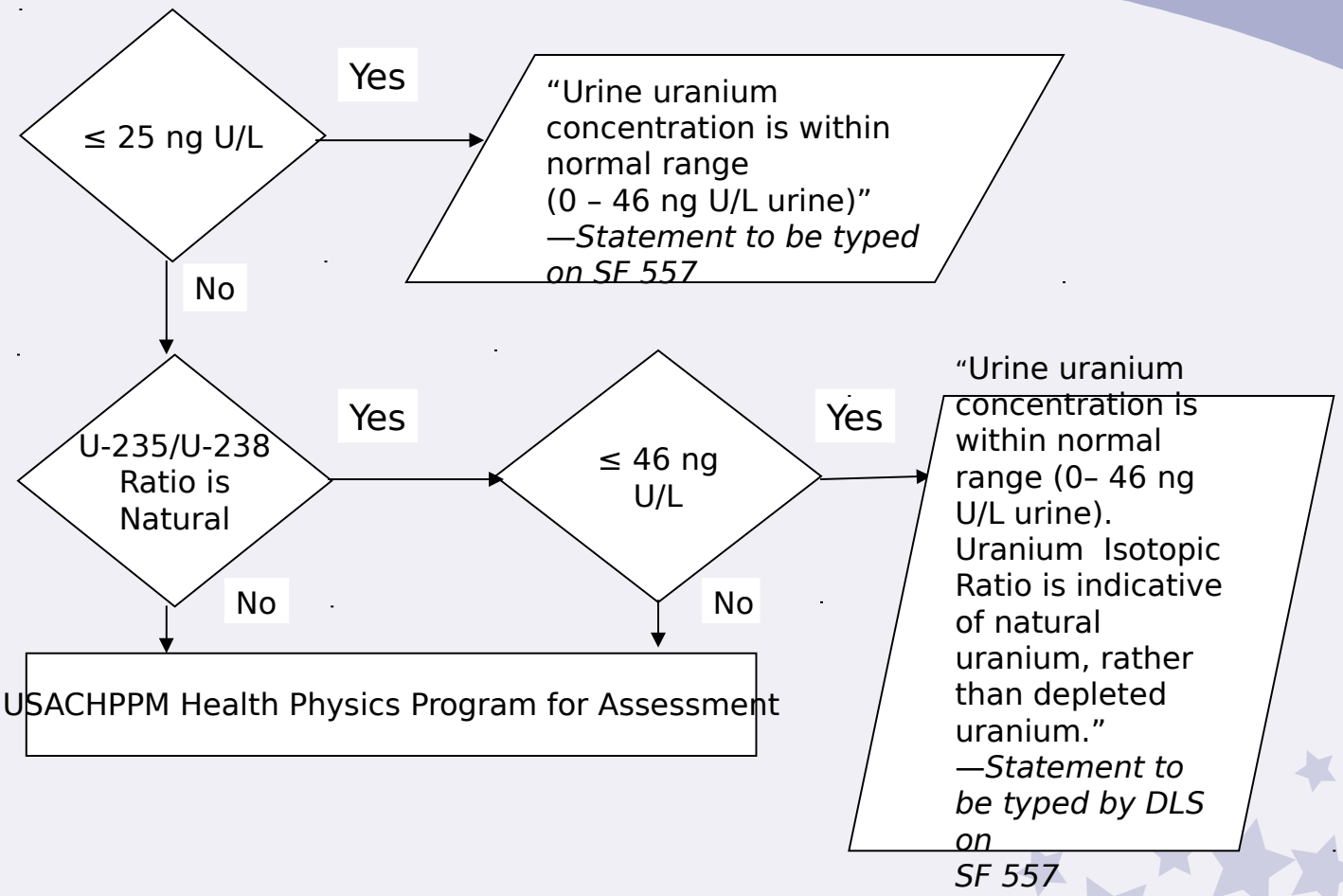
- Analysis for DU of metal fragments removed from patients with retained shrapnel
  - 39 metal fragments analyzed (from 34 patients)
  - 2 fragments positive for DU (from 1 patient)

Interpretation of DU Bioassay Results



Cautions Regarding Health Risk Assessments

- The Health Physics Society Position Statement on "Radiation Risk in Perspective" (January 1996) states "estimates of risk should be limited to individuals receiving a dose of 5 rem in one year or a lifetime dose of 10 rem in addition to natural background”
- Below these doses, risk estimates should not be used; expressions of risk should only be **qualitative** emphasizing the inability to detect any increased health detriment (zero health effects most likely outcome)

Purpose for DU Screening Bioassays

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- Identify Service Members with undiagnosed embedded DU fragments
- Provide reassurance to other potentially exposed Service Members

- More details to follow:
  - DoD Policy for the Operation Iraqi Freedom Depleted Uranium (DU) Medical Management
  - DHCC's Implementation of the DoD DU Policy – Care Management
  - VA Depleted Uranium Follow-Up Program